This document contains Part 1 (pp.209–224) of Chapter 8 of the National Coastal Condition Report III.

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National Coastal Condition Report III

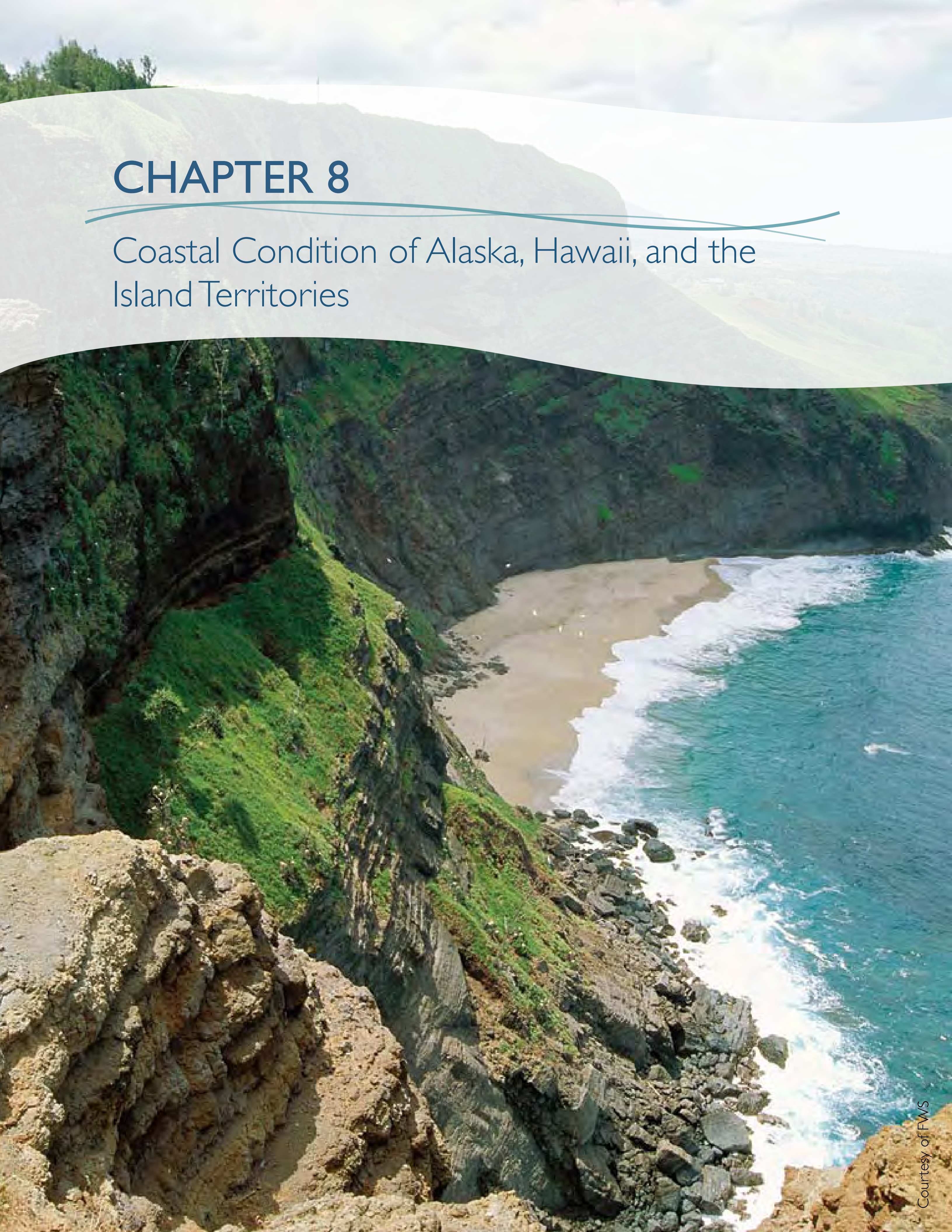
Chapter 8: Coastal Condition of Alaska, Hawaii, and the Island Territories

Part 1 of 2

December 2008

CHAPTER 8

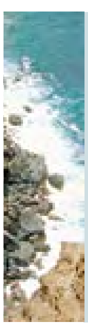
Coastal Condition of Alaska, Hawaii, and the Island Territories



Courtesy of FWS

Coastal Condition of Alaska, Hawaii, and the Island Territories

Currently, very little routine monitoring of coastal resources occurs in Alaska, Hawaii, and the island territories of the Pacific or Caribbean regions. EPA Regions 2 (Puerto Rico and U.S. Virgin Islands), 9 (Hawaii, Guam, the Northern Mariana Islands, and American Samoa), and 10 (Alaska), as well as the attendant state natural resource agencies, conduct some water quality monitoring, but it is often irregular and focused on specific locations or site-specific pollution problems. No consistent monitoring programs cover all of the coastal resources in these states, territories, and commonwealths. Efforts conducted through EPA's NCA are starting to fill this void for Alaska (ongoing), Hawaii, Puerto Rico, the U.S. Virgin Islands, Guam, and American Samoa; however, no plans are currently in place to survey conditions associated with the Northern Mariana Islands. This chapter briefly describes the surveys and presents the assessment findings from monitoring conducted in Southcentral Alaska and Hawaii during 2002. The southeastern region of Alaska was surveyed in 2004, and an assessment of the vast Aleutian Islands region of Alaska began in the summer of 2006, with field work completed during the summer of 2007. Puerto Rico, the U.S. Virgin Islands, Guam, and American Samoa were assessed in 2004–2005, and Hawaii was resurveyed in 2006; however, the results of these assessments were not available for inclusion in this report.



The NCA monitoring data used in this report were based on single-day measurements collected at sites throughout the United States during a 9- to 12-week period in late summer. Data were not collected during other time periods.

Alaska

The overall condition of Southcentral Alaska's coastal waters is rated good, based on three of the indices assessed by the NCA (Figure 8-1). The water quality, sediment quality, and fish tissue contaminants indices for Southcentral Alaska are each rated good, and the NCA was unable to evaluate the benthic and coastal habitat indices for this region. Figure 8-2 provides a summary of the percentage of coastal area in good, fair, poor, or missing categories for each index and component indicator. This assessment is based on environmental stressor and response data collected from 55 locations along Southcentral Alaska's coastline in 2002. Please refer to Chapter 1 for information about how these assessments were made, the criteria used to develop the rating for each index and component indicator, and limitations of the available data.

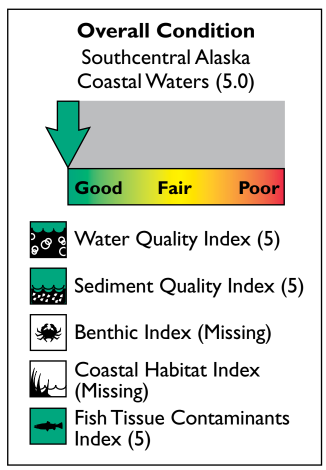


Figure 8-1. The overall condition of Southcentral Alaska's coastal waters is rated good (U.S. EPA/NCA).

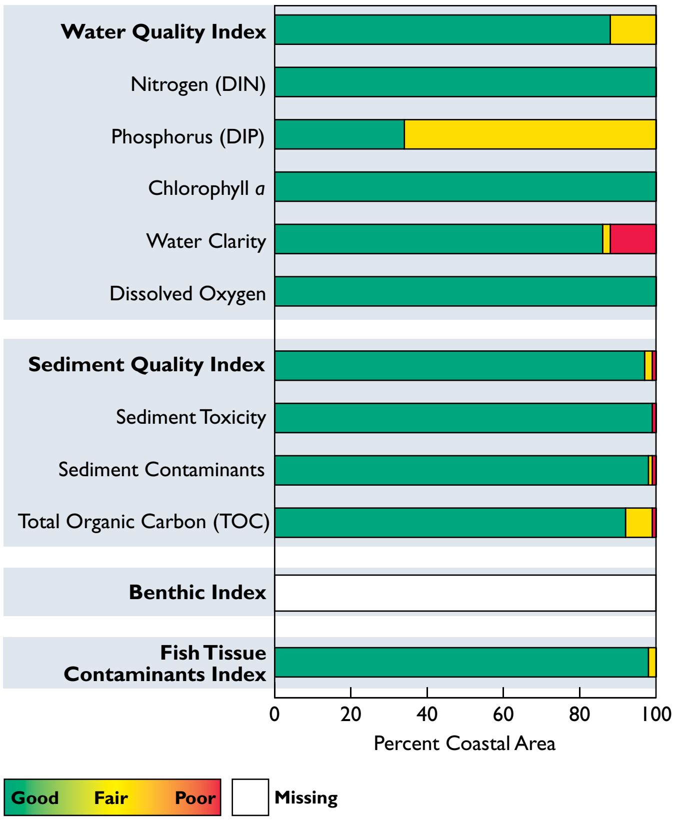


Figure 8-2. Percentage of coastal area achieving each ranking for all indices and component indicators–Southcentral Alaska (U.S. EPA/NCA).

Alaska has a marine shoreline length of approximately 45,000 miles, constituting more than 50% of total U.S. coastline miles. The surface area of coastal bays and estuaries in Alaska is 33,211 mi^2. Much of the southeast and southcentral coast of Alaska is very convoluted, and contains of hundreds of bays, estuaries, coves, fjords, and other coastal features. In addition, most of Alaska's extensive coastline is inaccessible by road, which makes a statewide coastal monitoring program both extremely difficult and expensive.

Alaska's coastal resources are often thought to be in pristine or near-pristine condition due to Alaska's low population density, the distance between most of its coastline and major urban or industrial areas, and the state's limited agriculture activities. Some contaminant concentrations have indeed been measured as having levels significantly lower than those in the rest of the coastal United States. For example, recent sampling of both commercial and subsistence fish for contaminants by the Alaska Department of Environmental Conservation (DEC) showed that organochlorine levels are very low (Alaska DEC, 2007). However, contaminants such as persistent organic pollutants (POPs) and mercury have been observed accumulating in the Alaska marine food web, raising ecological and human health concerns (AMAP, 2004a; 2004b). In a recent report, POPs were identified as a particular concern in Alaska, in part because of the subsistence lifestyle of many Native Alaskan communities (Chary, 2000).

Although localized pollution sources exist in Alaska, long-range atmospheric and oceanic transport from more-developed population and industrial centers are believed to be responsible for the majority of the contaminants deposited in Alaska. In addition, the state's coastal environment may represent long-term sinks for POPs and mercury due to the processes of cold condensation and the polar solar sunrise effect (AMAP, 2004a; 2004b). For example, even though this region has a low human population density, Steller sea lions and sea otters in the Aleutian Islands exhibit high levels of POPs and methylmercury than do specimens from other regions, such as California and southeastern Alaska (Bacon et al., 1999; Barron et al., 2003). Overall, the Arctic, including Alaska's coastal arctic region, is now seen as a potential sink for significant amounts of bioavailable mercury (Ebinghaus et al., 2004). Rapid economic development in Asia coupled with the long-range atmospheric transport of contaminants suggests the potential for increasing levels of some contaminants in Alaska (Wright et al., 2000; AMAP, 2004a; 2004b).

Prince William Sound, AK (courtesy of Commander John Bortniak, NOAA).

Between 1980 and 2003, coastal counties along the Alaskan Coast showed the largest rate of population increase (63%) of any coastal region in the entire United States. In addition, the population of Matanuska-Susitna County grew by more than 200%, which was the third-largest population change in the nation over that period of time. Figure 8-3 presents population data for Alaskan coastal counties since 1980 (Crossett et al., 2004).

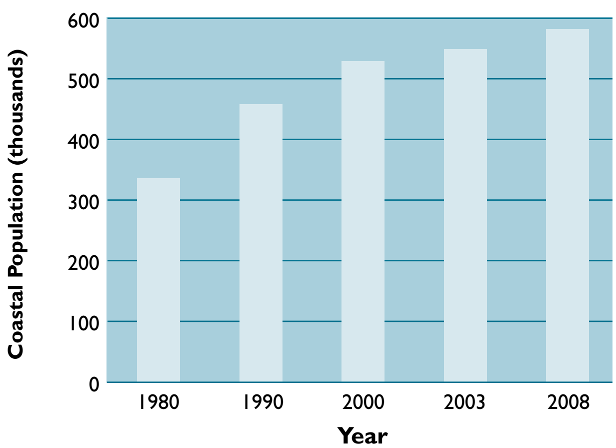


Figure 8-3. Actual and estimated population of coastal counties in Alaska from 1980 to 2008 (Crossett et al., 2004).

Coastal Monitoring Data—Status of Coastal Condition

In 2001, the NCA developed a sampling design in conjunction with the Alaska DEC and EPA Region 10 to assess all of the coastal resources in Alaska by monitoring 250 sites spread throughout the state. Because of the geographic expanse of Alaska, the reduced sampling window in Arctic regions, and the unique fiscal and logistical challenges of sampling the state's coastal resources, it was not feasible to survey the entire state at a single point in time. The NCA, EPA Region 10, Alaska DEC, and other state natural resource agencies determined that the sampling design for Alaska would be executed in five phases—Southcentral Alaska, Southeastern Alaska, the Aleutian Islands, the Bering Sea, and the Beaufort Sea (Figure 8-4). Each sampling phase surveys one of these five areas, and the target schedule for the completion of statewide surveys is 5 to 10 years. Before this collaboration between Alaska's resource agencies and EPA, the Alaska DEC routinely assessed only about 1% of the state's coastal resources, focusing its efforts on waterbodies known or suspected to be impaired (Alaska DEC, 1999). In June 2005, the Alaska DEC released its *Water Quality Monitoring*

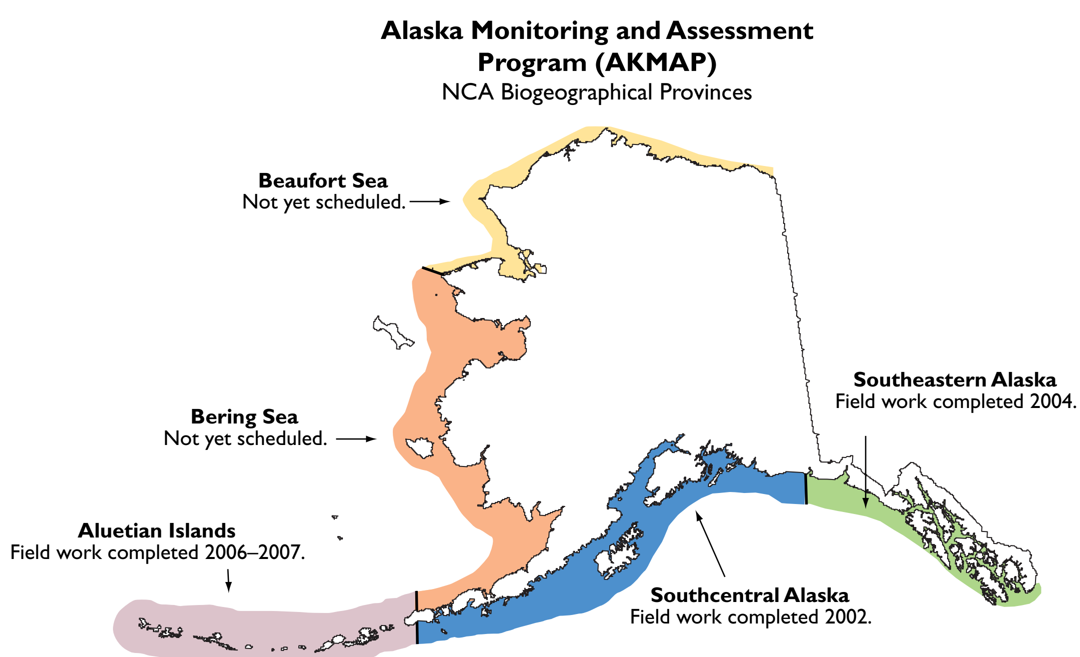
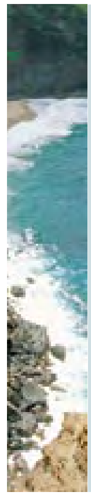


Figure 8-4. Five Alaskan provinces used in the NCA sampling design (Alaska DEC, Division of Water).

and Assessment Strategy and *Environmental Monitoring & Assessment Program Implementation Strategy* to guide its stewardship of Alaska's marine and freshwater resources (Alaska DEC, 2005b; 2005a).

In 2002, Alaska's southcentral coast (Alaskan Province) was selected as the first portion of the state to be assessed by the NCA because of the importance of this area's major estuarine resources (Prince William Sound and Cook Inlet) to aquatic living resources and to local and state economies. Due to the long distances between sites (even in this reduced area), the surveys were conducted using a large (100-foot), ocean-going research vessel equipped with a powered skiff for shallow-water work. The survey collected data at sites with approximate depths ranging from 13 to 1,155 feet. Many of the shallowest stations occurred in nearshore areas of Cook Inlet, which is known for wide intertidal depth fluctuations and extensive sediment depositional zones. The deepest stations were located in Prince William Sound. A report on the 2002 sampling effort in southcentral Alaska was produced by Alaska DEC (Saupe et al., 2005).

The environmental index and component indicator data collected during the survey of the southcentral region correspond to the parameters that will be collected in future surveys of the other regions. Alaska's southeastern coast (Juneau and the island passage area) was assessed by NCA in 2004, and a draft report on the results of this survey will be produced in 2008.



The sampling conducted in the EPA NCA survey has been designed to estimate the percent of coastal area (nationally or in a region) in varying conditions and is displayed as pie diagrams. Many of the figures in this report illustrate environmental measurements made at specific locations (colored dots on maps); however, these dots (color) represent the value of the index specifically at the time of sampling. Additional sampling would be required to define temporal variability and to confirm environmental condition at specific locations.

Water Quality Index

The water quality index for the coastal waters of Southcentral Alaska is rated good. This index was developed based on measurement of five component indicators: DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen. Most (88%) of the coastal area was rated good for water quality condition, with the remainder of the area rated fair (Figure 8-5). Fair conditions were largely due to elevated DIP concentrations or low water clarity measurements, both of which are likely the result of naturally occurring conditions and not human influences.

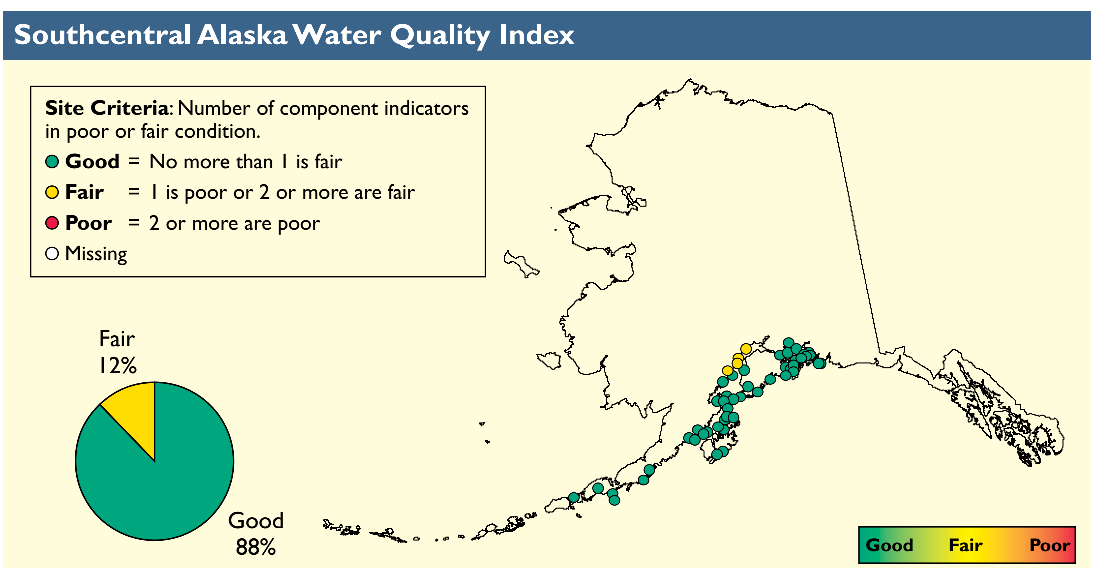


Figure 8-5. Water quality index data for Southcentral Alaska's coastal waters (U.S. EPA/NCA).

Nutrients: Nitrogen and Phosphorus

DIN concentrations in the coastal waters of Southcentral Alaska are rated good, with 100% of the coastal area rated good for this component indicator. DIP concentrations are rated fair for Southcentral Alaska's coastal waters, with 66% of the coastal area rated fair. The DIP levels may be of natural origin, based on historic data that suggest that seasonal upwelling brings in deeper, DIP-rich Gulf of Alaska waters into the lower waters of Cook Inlet. This seasonal supply of nutrients may account for the high productivity rates measured in late summer, which result in some of the most productive high-latitude shelf waters in the world (Larrance et al., 1977; Sambrotto and Lorenzen, 1986).

Chlorophyll *a*

Chlorophyll *a* concentrations in Southcentral Alaska's coastal waters are rated good, with 100% of the coastal area rated good for this component indicator. Although no areas of Southcentral Alaska showed high concentrations of water column chlorophyll *a*, this may not indicate low, land-based loadings of nitrogen and phosphorus. Many Alaskan waters have large intertidal areas, so nutrient utilization by benthic algae may be of greater importance than nutrient uptake by phytoplankton; however, data are not currently available to address this issue.

Water Clarity

Water clarity in the coastal waters of Southcentral Alaska is rated fair, with 12% of the coastal area rated poor for this component indicator. Water clarity was rated poor at a sampling site if light penetration at 1 meter was less than 10% of surface illumination. The coastal area rated poor represents only four sites, which were located in the Upper Cook Inlet area. At these sites, very high loadings of glacial river sediments occur during the summer peak-flow period. Three of the area's primary glacial rivers (the Knik, Matanuska, and Susitna rivers) have a combined peak discharge of about 24 million gallons/second in July and August and contribute, on average, more than 250,000 pounds of suspended sediment per day to Upper Cook Inlet (MMS, 1995). These waters then mix with the more saline waters in Cook Inlet and flow along the western edge of the Inlet to the Shelikof Strait. Thus, the low levels of light penetration observed at the four sampling sites are indicative of naturally occurring conditions representing summer high-flow inputs of suspended sediments at the time of sampling. During the period of low flow in the winter, glacial river inputs and suspended sediment loadings significantly decrease. In addition, the large tidal amplitude occurring along the Southcentral Alaska coast may contribute to the re-suspension of deposited glacial river sediments.

Dissolved Oxygen

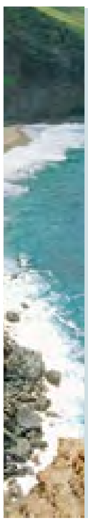
Dissolved oxygen conditions in the coastal waters of Southcentral Alaska are rated good, with 100% of the coastal area rated good for this component indicator. Although conditions in the Southcentral Alaska region appear to be generally good for dissolved oxygen, measured values reflect daytime conditions, and it is possible that some areas may still experience hypoxic conditions at night.

Sediment Quality Index

The sediment quality index for the coastal waters of Southcentral Alaska is rated good, with only 1% of the coastal area rated poor (Figure 8-6). The sediment quality index was calculated based on measurements of three component indicators: sediment toxicity, sediment contaminants, and sediment TOC. There were very few instances where any of the component indicators were rated either fair or poor.

Sediment Toxicity

Sediment toxicity for Southcentral Alaska's coastal waters is rated good, with only 1% of the coastal area rated poor. Sediment toxicity was determined using a static, 10-day acute toxicity test with the amphipod *Ampelisca abdita*. Although use of *Ampelisca* standardizes the sediment toxicity test within the EMAP/NCA process, this test may or may not reflect the actual response of the specific benthic organisms indigenous to Southcentral Alaska. The State of Alaska has yet to select specific benthic species for use in sediment toxicity studies, but considers the EMAP work important in supporting future efforts to develop a sediment toxicity test for Alaska. One of the sites rated poor for sediment toxicity also had the highest chromium and nickel concentrations of any of the sites sampled in Southcentral Alaska during this survey. These trace metals are likely elevated due to the historic chromium-mining operations in the vicinity of this site. The other site rated poor for sediment toxicity exhibited the highest percent TOC measurement (6.43%) of any NCA site sampled in Southcentral Alaska. These elevated TOC measurements were influenced by the large amount of decomposing eelgrass mixed in with this sediment sample. Elevated trace metal and TOC levels have been shown to be detrimental to some benthic organisms.



Guidelines for Assessing Sediment Contamination (Long et al., 1995)

ERM (Effects Range Median)—Determined for each chemical as the 50th percentile (median) in a database of ascending concentrations associated with adverse biological effects.

ERL (Effects Range Low)—Determined values for each chemical as the 10th percentile in a database of ascending concentrations associated with adverse biological effects.

Sediment Contaminants

The coastal waters of Southcentral Alaska are rated good for sediment contaminant concentrations, with 1% of the coastal area rated poor and 2% of the area rated fair for this component indicator. It should be noted that this evaluation of sediment contamination excluded nickel because the ERM value for this metal has a low reliability for areas of the West Coast, where high natural crustal concentrations of nickel exist (Long et al., 1995). A study of metal concentrations in cores collected along the West Coast determined the range of historic background concentrations of nickel to be 35–70 ppm (Lauenstein et al., 2000), which brackets the value of the ERM (51.6 ppm). Some researchers have also suggested that West Coast crustal concentrations for mercury may be naturally elevated; however, no conclusive evidence is available to support this suggestion. Therefore, mercury data were not excluded from this assessment of Southcentral Alaska's coastal waters. In addition, only one exceedance was counted if a site exceeded the ERL for low molecular weight PAHs, high molecular weight PAHs, and/or total PAHs to ensure that the analysis was not biased by PAHs. The site rated poor was located in Chrome Bay and exhibited elevated levels of chromium. The site rated fair was located in Prince William Sound, where elevated levels of metals (chromium, copper, zinc) and individual PAHs were detected.

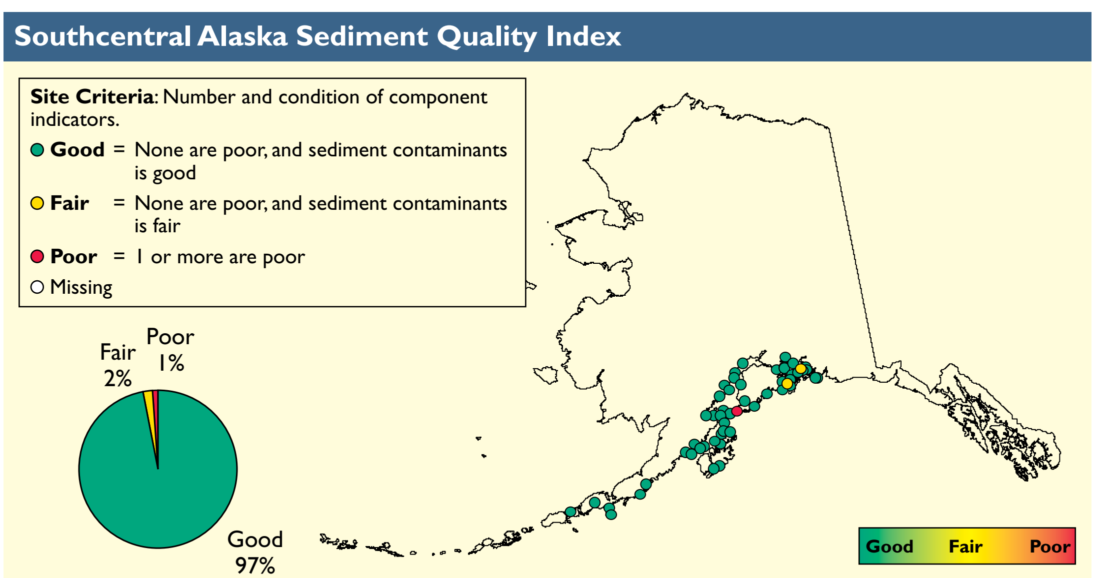


Figure 8-6. Sediment quality index data for Southcentral Alaska's coastal waters (U.S. EPA/NCA).

Highlight

The NCA Survey of the Aleutian Islands, Alaska, 2006–2007

Within the region known as the "Cradle of Storms," the Aleutian Islands stretch over a 1,180-mile span of ocean, jutting westward from the Alaska Peninsula to form an arc that separates the North Pacific Ocean from the Bering Sea. The Aleutian Islands are the exposed peaks of a submerged mountain range. Along the southern edge of the island arc is a curving submarine trench, which has depths as great as 24,930 feet and extends across the North Pacific for 1,990 miles from the Gulf of Alaska to Kamchatka Peninsula. The Aleutian Islands rose from the volcanic activity caused by the convergence of the Pacific and North American tectonic plates. Today, this region is one of the most seismically and volcanically active regions in the world, and new islands are still being created.

The marine environment around the Aleutian Islands consists of highly productive, biologically diverse marine ecosystems. Significant upwelling occurs in this region, bringing nutrients to the surface and creating a green belt of high levels of primary and secondary production along the Aleutian Arc. As a consequence, numerous species of fish, mollusks, crustaceans, birds, and marine mammals live in this region. Fisheries harvests in this region provide more than 50% of the nation's total harvest and around 10% of the global marine harvest of fish and shellfish (Alaska DCED, 2003). The Aleutian Islands are also within the major migratory pathways of many of the food species (e.g., fish, marine mammals) used for subsistence by the Aleut Natives.

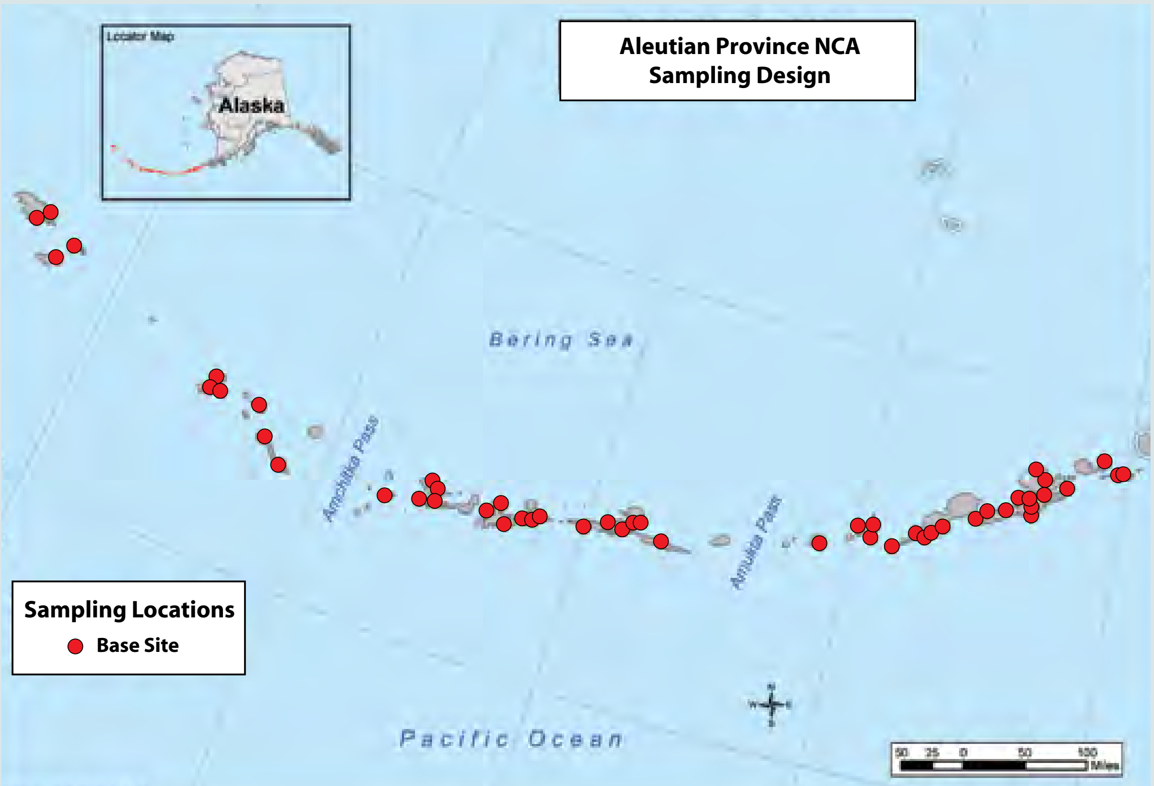
Although the Aleutians may seem remote, numerous portions of the islands have been contaminated with petroleum products, as well as with PCBs and several heavy metals. Many contaminated sites originated with World War II and subsequent Cold War activities. For example, Amchitka Island, which is located mid-way along the Aleutian Arc, was the site the United States' largest underground nuclear tests, and leakage of radionuclides from this nuclear testing into the marine environment remains a long-term concern. International shipping activities may also contribute contaminants to the environment. In 2004, the *M/V Selendang Ayu* lost an estimated 321,052 gallons of intermediate fuel oil and 14,680 gallons of marine diesel fuel, in addition to its cargo of approximately 60,000 tons of soybeans, into the marine environment (Alaska DEC, 2006). Hundreds of ships a year travel along a major Pacific shipping route between the West Coast and Asia through the Aleutian Island chain. As the Arctic ice pack recedes due to climate change, a major increase in shipping through this region is expected to occur

The Aleutian Islands host the largest nesting population of seabirds in North America (courtesy of FWS).

as the northern sea routes open up for longer periods. Increased shipping traffic has the potential for increasing environmental impacts. In addition, pollutants from Pacific Rim countries are delivered to the Aleutians by the wind and ocean currents and pose potential threats to the marine ecosystem.

To complete the NCA survey of the Aleutian Islands personnel from the Alaska DEC served in the lead role, and support was provided from personnel from the University of Alaska Fairbanks and other state and federal agencies. The Aleutian component of the NCA survey is based on a combination of the procedures and methods of the NCA coupled with specialized methods for sampling hard- bottom habitats. The specialized methods were first developed for the 2002 NCA assessment in Hawaii (Nelson et al., 2007). A total of 50 randomly selected sites (see map) between the 0 and 60-foot depth contours sampled during the summers of 2006 and 2007 (25 sites per year). The 2-year duration period for the sampling effort was dictated by the long cruising distances between sampling stations and the difficult logistics of sampling in the Aleutian Islands.

The extent and effects of numerous anthropogenic stressors, ranging from impacts of commercial fisheries to invasive species, need to be understood if resource managers are to preserve and protect the ecological diversity of this coastal resource. The NCA survey in the Aleutian Islands will provide the Alaska DEC with the ability to assess the current ecological status and, as future assessments are completed, to assess trends in contaminant levels and ecosystem changes in the region.



Sampling locations for the 2006–2007 NCA survey of the Aleutian Islands (U.S. EPA/NCA).

Sediment TOC

The coastal waters of Southcentral Alaska are rated good for the sediment TOC component indicator. One site, representing about 1% of the area of the Southcentral Alaska's coastal waters, was rated poor. The poor rating at this site was influenced by the large amount of decomposing eelgrass present in this sediment sample. Another 7% of the coastal area was rated fair. These sites are spatially separated, span a range of depths, and presumably contain elevated levels of organic matter deposited from natural rather than anthropogenic sources.

Benthic Index

The benthic index for the coastal waters of Southcentral Alaska could not be evaluated. Although several efforts are underway and indices of benthic community condition have been developed for some regions of the West Coast (e.g., Smith et al., 1998), there is currently no benthic community index applicable for Southcentral Alaska. In lieu of a benthic index for Southcentral Alaska, the deviation of species richness from an estimate of expected species richness was used as an approximate indicator of the condition of the benthic community. This approach requires that species richness be predicted from salinity, and, in the case of the Southcentral Alaska survey data, the regression was not significant.

Coastal Habitat Index

Although estimates of habitat loss are available for Alaska as a whole, data were not available to correspond with the geographic region sampled by the NCA survey; therefore, a coastal habitat index could not be calculated for the coastal waters of Southcentral Alaska.

Fish Tissue Contaminants Index

The fish tissue contaminants index for the coastal waters of Southcentral Alaska is rated good. Two percent of the stations where fish were caught were rated fair due to mercury concentrations within the range of concern (Figure 8-7). This percentage represented one composite sample made up of three fish from one sampling station.

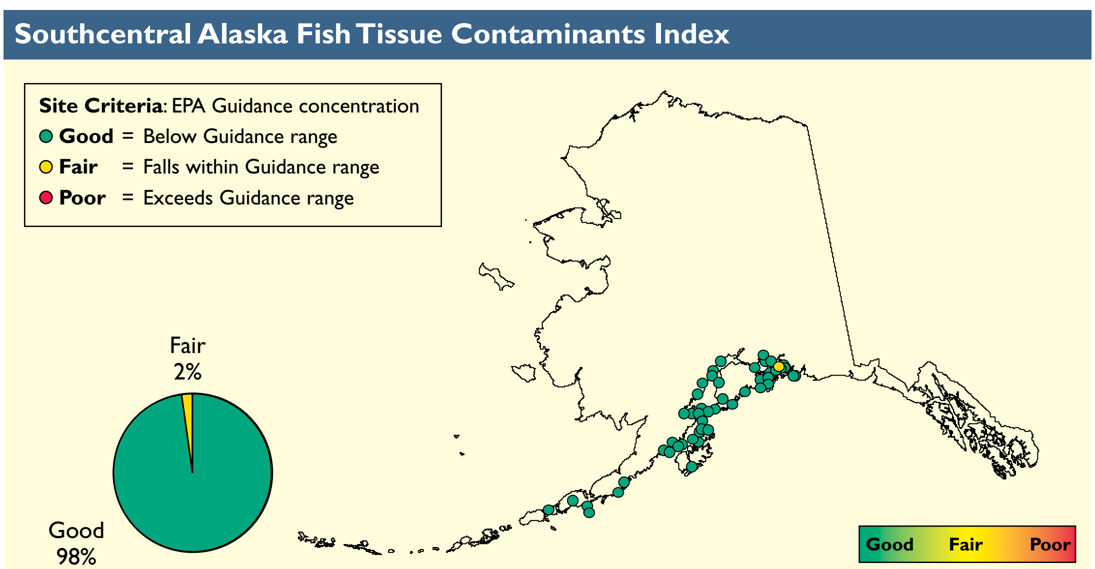


Figure 8-7. Fish tissue contaminants index data for Southcentral Alaska's coastal waters (U.S. EPA/NCA).

Snow-covered mountains meet the sea near Girdwood, AK (courtesy of Dave LaForest).

Trends of Coastal Monitoring Data—Southcentral Alaska

The 2002 NCA survey of Southcentral Alaska coastal waters was the first probabilistic survey of its kind in the state. Historically, coastal assessments have focused on areas of known or suspected impairment to examine the impacts of natural resource extraction activities, such as mining or oil exploration and production. One large-scale assessment occurring before resource development was the Alaska Outer Continental Shelf Environmental Assessment Program, conducted by NOAA in the 1970s. A large amount of physical, chemical, and biological data were collected through this program. Although much of these data remain difficult to locate, a summary may be found in Hood and Zimmerman (1986). Numerous assessments have also been conducted along the portion of Alaska's coastline affected by the Exxon Valdez oil spill in 1989, and this area continues to be monitored. In addition, several programs have provided an assessment of contaminants in Alaska as part of larger national assessments. For example, NOAA's NS&T Program analyzed contaminants in sediments and demersal (bottom-dwelling) fish at several sites along Alaska's coast as part of its Benthic Surveillance Program and measured contaminants in intertidal mussels and sediments as part of its Mussel Watch Program. Due to a lack of comparable data in the region, trends could not be evaluated for Southcentral Alaska's coastal waters at this time.

Large Marine Ecosystem Fisheries—Gulf of Alaska and East Bering Sea LMEs

Alaska is surrounded by 4 sub-arctic LMEs (Figure 8-8). The Beaufort Sea LME is located off the northern coast of Alaska and stretches eastward into Canadian waters. West of the Beaufort Sea LME is the Chukchi Sea LME, which is located off the northwest coast of Alaska and extends westward to the northeast coast of Siberia in Russia. The East Bering Sea LME, which is located off the west coast of Alaska, extends from the Bering Strait, through the Bering Sea, and southward into the Pacific Ocean. Alaska's southern coast is bordered by the Gulf of Alaska LME, which extends along the coastline from the Alaska Peninsula southward through Canada to the northwestern coast of Washington (NOAA, 2007g). Only the fisheries in the East Bering Sea and Gulf of Alaska LMEs will be discussed in this chapter.

The East Bering Sea LME is considered to have moderately high productivity based on estimates of primary production (phytoplankton). The LME is characterized by a wide shelf and has historically had seasonal ice cover of up to 80% in March (NOAA, 2007g). More recent winter temperatures have been above the freezing point, indicating little or no sea ice in the southeastern East Bering Sea LME between 2000 and 2004 (NOAA, 2007a). Accompanying this change is a shift in the trophic structure of the ecosystem, with walrus population centers moving northward with the ice and an eastward extension in the movement of Alaska pollock (Overland and Stabeno, 2004).

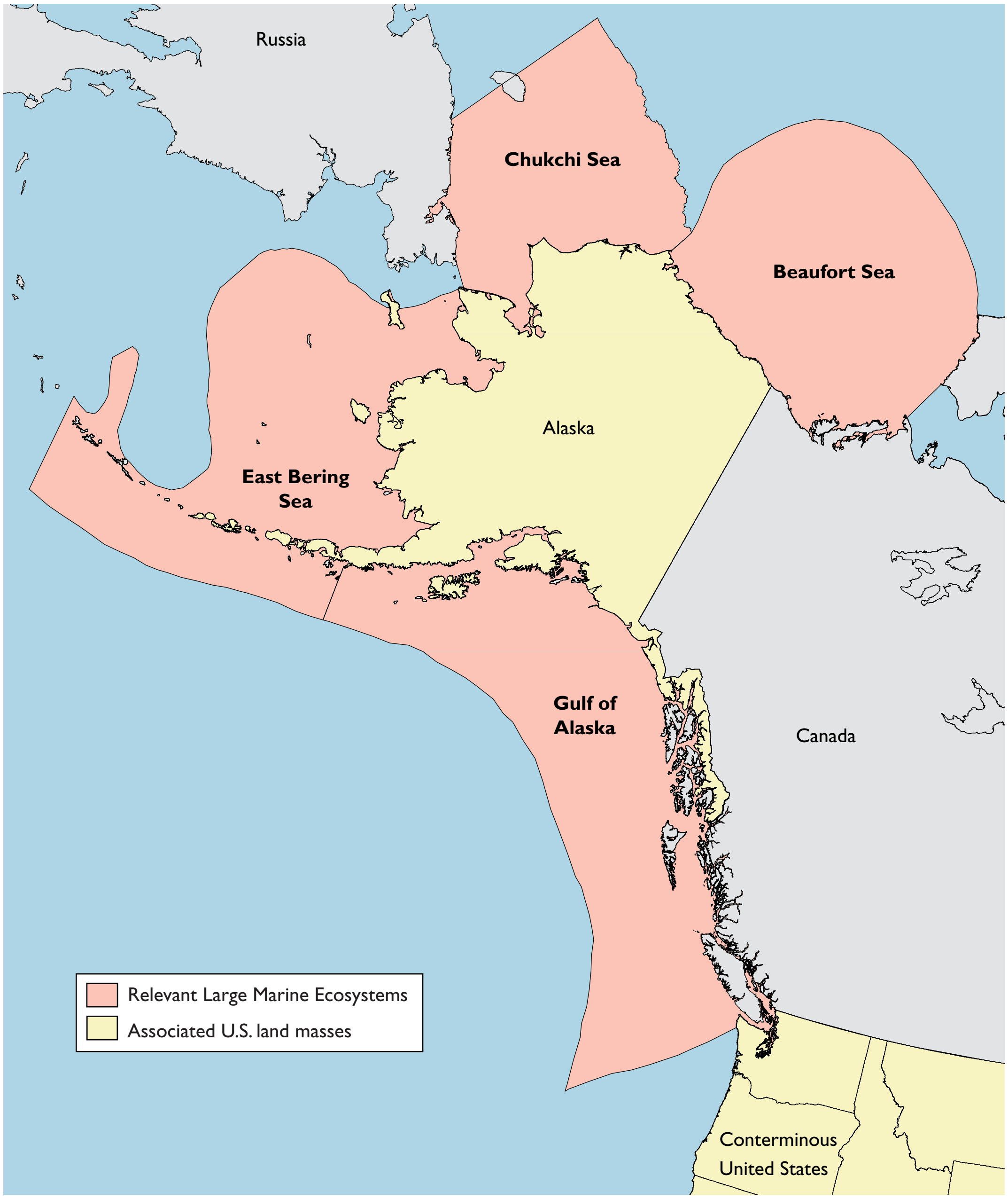


Figure 8-8. Alaska is surrounded by 4 LMEs (NOAA, 2007g).

Recruitment responses of many East Bering Sea LME fish and crabs are linked to decadal-scale patterns of climate variability. Decadal-scale changes in the recruitment of some flatfish species in the East Bering Sea LME appear to be related to patterns seen in atmospheric forcing. The Arctic Oscillation and Aleutian Low are two examples of atmospheric forcing in this LME. The Arctic Oscillation tracks the variability in atmospheric pressure at the polar region and mid-latitudes and tends to vary between negative and positive phases on a decadal scale. The negative phase brings higher-than-normal pressure over the polar region, and the positive phase does the opposite, steering ocean storms farther north. In winter, these patterns in atmospheric condition may influence surface wind patterns that transport fish larvae on or off the continental shelf. The recruitment (addition of a new generation of young fish) of some species (e.g., Bering Sea herring, walleye pollock, and Pacific cod) shows interannual variability that appears more related to climate variability. Years of strong onshore transport, typical of warm years and the negative phase of the Arctic Oscillation in this LME, correspond with strong recruitment of walleye pollock, possibly due to separation of young fish from cannibalistic adults. Alaskan salmon also exhibit decadal-scale patterns in production, and these patterns are inversely related to salmon production patterns in the California Current LME (discussed in Chapter 6). An Aleutian Low is a low-pressure cell located near the Aleutian Islands, and strength variations in this cell can affect wind directions and larvae transportation patterns. For example, periods of strong Aleutian Lows are associated with weak recruitment for some East Bering Sea LME crab species and are unrelated to recruitment of others, depending on species-specific life-history traits. Winds from the northeast favor retention of crab larvae in offshore mud habitats that serve as suitable nursery areas for young Tanner crabs to burrow in sediment for protection (Livingston and Wilderbuer, 2007). Winds from the opposite direction promote the inshore transport of crab larvae to coarse, shallow-water habitats in inner Bristol Bay, which serve as nursery areas for red king crabs to find refuge among biogenic structures (Rosenkranz et al., 1998; 2001; Livingston and Wilderbuer, 2007). The timing and composition of the plankton blooms may also be important because red king crab larvae prefer to consume diatoms (phytoplankton), whereas Tanner crab larvae prefer copepod nauplii (zooplankton) (Livingston and Wilderbuer, 2007).

Similar to the East Bering Sea LME, the Gulf of Alaska LME is sensitive to climate variations on time scales ranging from interannual to interdecadal. These variations and large-scale atmospheric and oceanographic conditions have an effect on the overall productivity of the LME, including plankton production and plankton species composition. The Gulf of Alaska LME presents a significant upwelling phenomenon linked to the Alaska Current and is considered a highly productive ecosystem based on primary productivity estimates. Changes in zooplankton biomass have been observed in both the Gulf of Alaska LME and the California Current LME directly to the south. These biomass changes appear to be inversely related to each other (NOAA, 2007g).

Salmon Fisheries

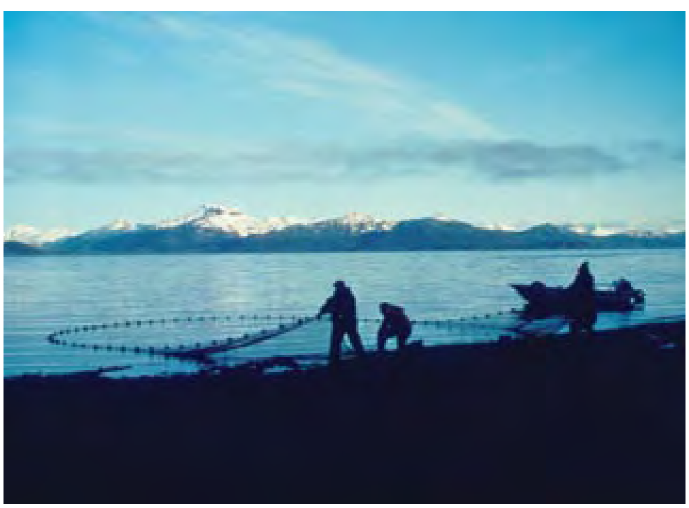
The abundance index for Pacific salmon is currently high in the Gulf of Alaska LME. The contributing factors to the high abundance index include (1) habitats with minimal impacts from extensive development, (2) favorable ocean conditions that promote high survival rates of juveniles, (3) improved management of the fisheries by state and federal agencies, (4) elimination of high-seas drift net fisheries by foreign nations, (5) hatchery production, and (6) reduction of bycatch in fisheries for other finfish species. Quality spawning and nursery habitat, favorable oceanic conditions, and sufficient numbers of spawning fish are most likely the paramount factors affecting current abundance levels. Alaska salmon management continues to focus on maintaining pristine habitats and ensuring adequate escapements; however, ocean conditions that favored high marine survival rates in recent years can fluctuate due to interdecadal climate oscillations. Recent evidence indicates that a change in the ocean conditions of the northern Pacific Ocean and the Gulf of Alaska LME may be underway, possibly reflecting the downturn in the abundance index for Alaska salmon runs observed in 1996 and 1997. Historic commercial landings show a distinct cyclic pattern of alternating high and low harvests, often lasting decades. Much of this fluctuation is now believed to be due to interdecadal climate oscillations in the ocean environment that affect the marine survival of juveniles. A pattern associated

Chinook salmon (courtesy of USGS).

with Alaska's cyclic salmon harvest appears to be inversely related to abundance patterns for California Current LME salmon (NMFS, In press).

All five species of Alaska salmon (pink, sockeye, chum, coho, and Chinook) are fully utilized, and stocks in most regions of the Gulf of Alaska and East Bering Sea LMEs have rebuilt to near or beyond previous high levels. Although there has been a high abundance index for salmon in these LMEs, there are issues of serious concern for salmon stocks, especially for some species and regions. For example, stocks in western Alaska, especially Chinook and chum salmon, have generally been at depressed levels since the mid-1990s. Some of the same issues implicated in the declines of California Current LME salmon stocks are also of concern in certain areas of Alaska. These issues include overfishing, incidental take of salmon as bycatch in other fisheries, and loss of freshwater spawning and rearing habitats (NMFS, In press).

Alaska commercial salmon harvests generally have increased during the past three decades. After reaching record-low catch levels in the 1970s, most populations rebounded, and fisheries in recent years have been at or near all-time peak levels in many regions of the Gulf of Alaska and East Bering Sea LMEs. The record-high commercial landings of 218 million salmon in 1995 were 17% higher than the previous record of 196 million salmon in 1994.



Beach seining for juvenile pink and chum salmon (courtesy of NOAA, Auke Bay Laboratories).

Throughout the mid-to-late 1990s, recreational and subsistence fishermen harvested between 2 and 3 million salmon annually (NMFS, In press).

Pelagic Fisheries

Pacific herring is the major pelagic (water-column-dwelling) species harvested in the Gulf of Alaska and East Bering Sea LMEs. These fisheries occur in specific inshore spawning areas. In the Gulf of Alaska LME, spawning fish concentrate mainly off of southeast Alaska in Prince William Sound and around the Kodiak Island-Cook Inlet area. In the East Bering Sea LME, the centers of abundance are in northern Bristol Bay and Norton Sound.

The Gulf of Alaska LME herring industry began as early as 1878, when 30,000 pounds were marketed for human consumption. The fishery expanded rapidly in the late 1800s and early 1900s, with markets shifting from salt-cured herring to reduction products for fishmeal and oil. By 1934, the catch from the Gulf of Alaska LME alone had reached a record 140,000 t. The East Bering Sea LME fishery began in the late 1920s, initially with a small salt-cure plant in Dutch Harbor. A large, foreign offshore fishery developed in the 1950s. Catches in this LME peaked in 1970 at over 145,000 t and then fell off sharply to 16,000 t in 1975. Since 1977, East Bering Sea LME herring have been harvested primarily in inshore sac roe fisheries, and catches have risen slowly, but steadily, since that time. A portion of the East Bering Sea LME harvest is taken as bycatch in the offshore federally managed demersal fish fishery. Retention of herring in these fisheries is prohibited, with regulations limiting herring bycatch to no more than about 1,000 t annually (NMFS, In press).

Currently, the herring stocks in both LMEs remain at moderate levels and are in relatively stable condition, with the exception of populations in the Prince William Sound and Cook Inlet areas. Populations of Prince William Sound herring continue to be depressed from a disease outbreak in 1993. In more recent years, Alaska herring harvests have averaged about 35,000 t, with a value of around $10 million (NMFS, In press).

Demersal Fish Fisheries

The demersal fish complex is the most abundant of all fishery resources in the Gulf of Alaska and the East Bering Sea LMEs, with an estimated biomass of more than 26.4 million t. From 1999 to 2001, demersal fish catches from these LMEs averaged 1.8 million t. Prior to 1976, the only demersal fish species of significant commercial value to domestic fisheries was Pacific halibut, with foreign fisheries harvesting most other targeted commercial species. The Magnuson-Stevens Fishery Conservation and Management Act extended federal fisheries management jurisdiction to 200 nautical miles offshore and stimulated the growth of a domestic Alaskan demersal fish fishery that rapidly replaced the foreign fisheries. Much of the demersal fish catches are exported, particularly to Asia, and such trade contributes prominently as a major source of revenue for U.S. fishermen (NMFS, In press).

Demersal fish biomass in the East Bering Sea LME has been maintained at relatively high levels since implementation of the Magnuson-Stevens Act. Walleye pollock produce the largest catch of any single species inhabiting the EEZ. The recent average yield for East Bering Sea LME (including the Aleutian Islands) demersal fish from 2001–2003 was just over 1.9 million t, compared to the 1997 catch of 1.74 million t. The dominant species harvested were walleye pollock (76%), Pacific cod (10%), yellowfin sole (4%), Atka mackerel (3%), and rock sole (2%). The Eastern Bering Sea LME stock can be considered to be slightly underutilized because its catch quota has been reduced from the full current yield to reduce the risk of overfishing and to mitigate the food competition with species that prey on pollock, including marine birds and the threatened and endangered Steller sea lion populations (NMFS, In press).

The demersal fish abundance index for the Gulf of Alaska LME has increased since 1977, peaking at an estimated biomass of 5.3 million t in 1982 and 1988, and most recently, at 5.49 million t in 1997. Since then, the estimated biomass has remained relatively stable, fluctuating between about 4 and 5 million t. The recent average yield for Gulf of Alaska LME demersal fish was nearly 200,000 t for 2001–2003. Gulf of Alaska LME demersal fish catches have ranged from a low of 129,640 t in 1978 to a high of 352,800 t in 1984. Demersal fish catches are dominated by walleye pollock, followed by Pacific cod, flatfish, and rockfish. Since 1989, demersal fish catches have fluctuated around 200,000 t. The pollock abundance index increased dramatically during the 1970s, peaked in the mid-1980s, and subsequently declined. The current abundance index is similar to stock size in the early 1970s. Current evidence suggests that extreme variation in the pollock abundance index is primarily a result of environmental forcing. Pollock are carefully managed due to concerns about fishery impacts on the endangered and threatened populations of Steller sea lions because pollock is a major prey item of Steller sea lions in the Gulf of Alaska LME. Sea lion protection measures include closed areas around rookeries and "haul outs" (areas where sea lions rest onshore); division of the western-central Gulf of Alaska LME pollock total allowable catch over 3 years and four seasons; and use of a more conservative harvest policy to determine the acceptable biological catch. The pollock stock in this area is considered fully utilized, and Pacific cod stocks are considered healthy and fully utilized. In general, flatfish stocks are abundant, largely due to great increases in arrowtooth flounder biomass, and underutilized due to halibut bycatch considerations. Rockfish (e.g., slope rockfish, pelagic shelf rockfish, thornyhead rockfish, demersal shelf rockfish) are conservatively managed due to their long life spans and consequent sensitivity to over-exploitation (NMFS, In press).

Yelloweye rockfish, *Sebastes ruberrimus*, are the target of a commercial longline fishery in Southeastern Alaska (courtesy of NOAA, National Undersea Research Program and the Alaska Department of Fish and Game).

Shellfish Fisheries

Major shellfish fisheries were developed during the 1960s in the Gulf of Alaska LME and subsequently expanded to the East Bering Sea LME. Shellfish landings in 2003 generated an estimated ex-vessel value of $181.6 million, compared with the ex-vessel value of $151 million in for 1997; king and snow crabs account for a majority of this value ($161 million) (NMFS, In press).

Three king crab species (red, blue, and golden or brown) and two Tanner crab species (Tanner crab and snow crab) have traditionally been harvested commercially in these two major LMEs of Alaska. Alaska crab resources are fully utilized, and quotas, seasons, and size and sex limits restrict catches to protect the crab resource and maintain product quality. Landings are limited to large male crabs, and seasonal closures are set to avoid fishing during times when crabs are molting or mating, as well as during soft-shell periods. In 2004, two Alaska crab stocks (the St. Matthew Island blue king crab stock and the Eastern Bering Sea Tanner crab stock) were determined to be overfished (NMFS, In press). There are rebuilding plans for these stocks (NPFMC, 2000a; 2000b), and fishing of these species is not allowed. Since 1999, exploratory fisheries on new deep-water stocks of scarlet king crab, grooved Tanner crab, and triangle Tanner crab have begun; however, they have produced only minor landings to date (NMFS, In press).

The northern pink shrimp is the most important of the five species that comprise Alaska shrimp landings. The domestic shrimp fishery in western Gulf of Alaska LME waters is currently at a low level, and shrimp abundance is too low in the Bering Sea to support a commercial fishery. The western Gulf of Alaska LME has been the main area of operation for Alaska's shrimp fishery, with shrimp landings indicating that catches in this area rose steadily to about 58,000 t in 1976 and then declined precipitously. As with crabs, the potential yields of shrimp stocks in both LMEs are not well understood (NMFS, In press).

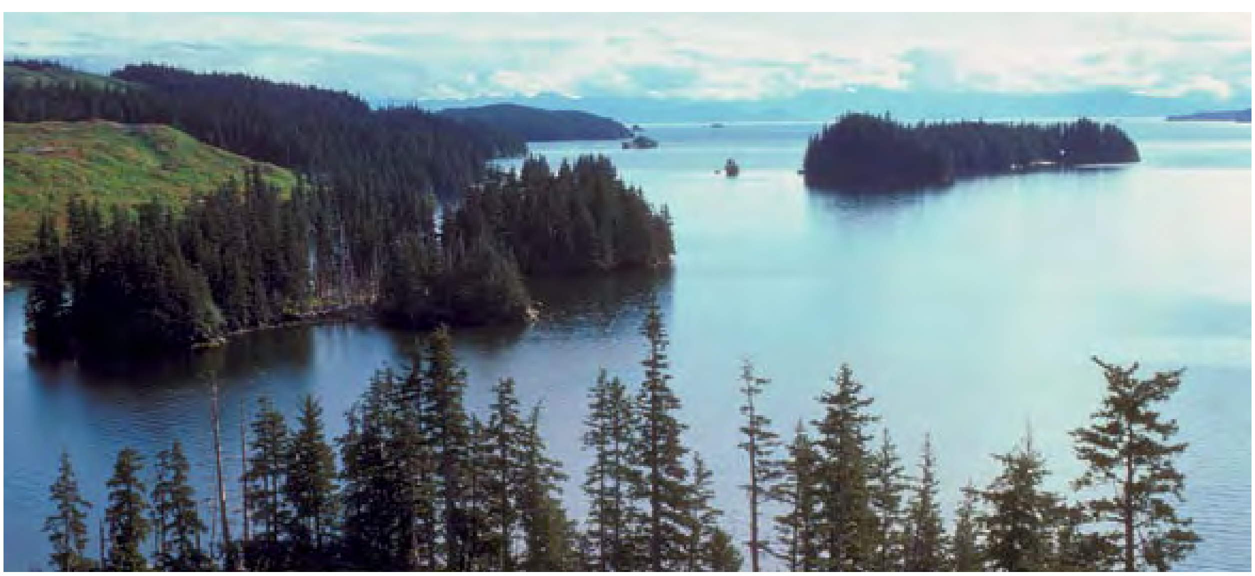
Assessment and Advisory Data

Fish Consumption Advisories

In 2003, no consumption advisories were in effect for chemical contaminants in fish and shellfish species harvested in Alaskan waters (U.S. EPA, 2004b).

Beach Advisories and Closures

Alaska did not report monitoring, advisory, or closing information for any beaches in 2003 (U.S. EPA, 2006c).



Kazakof Bay, AK (courtesy of Poppy Benson, FWS).